1 INTRODUCTION

1.1 Background, motivation and statement of problem

Sustainable economic growth needs guaranteed sources of raw materials for the industrial production. Nowadays, petroleum, a non-renewable resource is the most important source of industrial chemicals. As petroleum sources are been exhausted and causes environmental pollutions, there is a growing effort to make biomass as an alternative source of raw materials for sustainable growth. Polymers are an important class of industrial product and are mainly been synthesized from petroleum based raw materials which need to be replaced by the bio-based raw materials to make it sustainable. One of the industrial polymers is alkyd resin which is also known as bioresin. Bioresin is a polyester comprising of one or more reacted di-acid monomer units and one or more reacted diol monomer units where at least one of the reacted di-acid monomer units or at least one of the reacted diol monomer units is a bio-monomer obtained from a plant or an animal source (Urban & Owada, 2012). Alkyd resins are formed from the polymeric condensation of polyhydric alcohols, polybasic acids and monobasic fatty acids. Alkyds are used in the formulation of paints, varnishes, lacquers and other finishes, which make alkyd resins as a necessary raw material (Odetoye T. O., 2012). Alkyd resins are used in surface coating and composite formation due to their good characteristic such as strength, flexibility, gloss retention, good thermal stability and low price (Ling, 2014).

Oil is one of the important raw materials used in the production of oil modified alkyd resins. Vegetables oils are commonly and widely used in the manufacture of oil modified alkyd resins. Alkyd resin can be synthesized from both edible and non-edible vegetable oil sources. Non-edible oil is preferred to be used as an alternative source to synthesis alkyd resin due to its lack of food value. Among non-edible oils, jatropha (Kumar, Yaakob, Maimunah, Siddaramaiah, & Abdullah, 2010), nahar (Dutta, 2004), yellow oleander (Deka. D.C., 2011) and karanja (Millettia pinnata) (Bora, Deka, Ahmed, & Kakati, 2014) oil are been investigated as potential source for the preparation of oil modified alkyd resin. Alkyd resin can significantly reduce or remove the risk associated with cross-linking agents used in other resin systems, such as sulphur in furan based resins. By using plant oils, it can creates polymers with a greater intra-chain
length compared to the traditional resins. On curing, this property produces a structure that can be less brittle (providing flexibility before mechanical failure) allowing for improved impact resistance in structural applications.

Malaysia is rich in palm oil production, which known as non-drying oil due to the presence of low degree of unsaturation. Unsaturated oils are been preferred to produce bioresin due to the higher degree of cross-linking through the double bonds. Jatropha oil is one of the promising raw materials for bioresin synthesis, as it contains a high percentage of monounsaturated oleic (44.7%) and polyunsaturated linoleic acids (32.8%) (E., Z., S.K., M., & J., 2009) indicating a semi-drying property (Odetoye T. O., 2012). To the authors knowledge, there is no study reported the blending of palm oil with jatropha oil to produce bioresin. However, the blending of non-drying oil with semi-drying oil might increase the curing rate of the non-drying oil.

Furthermore, in recent years, metal nanoparticles are extensively studied to enhance the properties of the nanocomposites made from the bioresin. Pronob et al. reported the use of NiO nanoparticle on the properties of Jatropha oil based alkyd resin and epoxy blend, where the incorporation of the nanoparticle reduced the mobility of the polymer chain and increased the mechanical properties by many times. Zinc oxide nanoparticle, a multifunctional inorganic material, has drawn attention in recent years due to its outstanding physical and chemical properties, such as chemical stability, low dielectric constant, high luminous transmittance, high catalyst activity, effective antibacterial and bactericide, intensive ultraviolet and infrared absorption. Moreover, the incorporation of ZnO nanoparticles could improve the mechanical and optical properties of the polymer matrix (Omid, et al., 2011). However, the curing behaviour of the alkyd resin or the resin blends by incorporation of the metal oxide nanoparticles are not reported well throughout the literature. Hence in the present study attempts were made to prepare bioresin from jatropha and palm oil blend (1/1 wt % ratio) and the effect of ZnO nanoparticle on the curing behaviour of the composite have been investigated. Furthermore, bioresin/epoxy blend and its curing behaviour with and without ZnO nanoparticle have been studied.
1.2 Objectives

The following are the objective of this research:

- To study the effect of zinc oxide nanoparticle on the curing kinetic of bioresin.

1.3 Scope of this research

The following are the scope of this research:

i) To synthesized nanoparticles through sol gel method. The prepared nanoparticle was applied as catalysts during curing process.

ii) To synthesized bioresin by using two stages of alcoholysis-polyesterification method by mixing palm oil, jatropha oil, glycerol and phthalic anhydride.

iii) To prepared nanocomposite by mixing bioresin and nanoparticles via ultrasonic method. The curing kinetics of nanocomposite was investigated by using DSC method and its durability is checked by antimicrobial test.

1.4 Organisation of this thesis

The structure of the reminder of the thesis is outlined as follow:

Chapter 2 provides a description of preparation method of alkyd resin from various type of non-edible vegetable oil such as yellow oleander (*Thevetia peruviana*), karanja (*Millettia pinnata* (L.) Panigrahi) and jatropha *curcas* Linneaus. Fatty acid composition of Jatropha curcas oil seed, palm kernel oil, sunflower oil, soybean oil and palm oil was compared. Blending of oil modified alkyd resin with synthetic resin such as epoxy, acrylic and melamine was observed. The preparation and characterization of blends of alkyd resin and palm oil also been studied. Various physico-chemical properties such as density, viscosity, drying time, acid value, peroxide value and dry extract are observed. The effect of zinc oxide (ZnO) nanoparticle on the thermal degradation kinetics and mechanical properties of epoxy resin and nickel oxide (NiO) nanoparticles on the performance characteristics of the Jatropha oil based alkyd and epoxy blends have been reported. The curing behaviour of the resin was analysed by differential scanning calorimeter (DSC).

Chapter 3 gives a review on the process to study the effect of zinc oxide nanoparticles on curing kinetic of alkyd resins. The process starts from the synthesis of zinc oxide